Texture Evolution and Crystallography in Coated Conductors Based on Inclined Substrate Deposition

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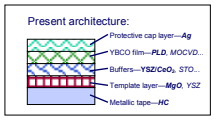
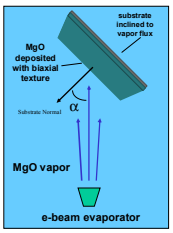
Motivation

Coated conductors are wires or tapes that are synthesized by depositing the high temperature superconductor $YBa_2Cu_3O_x$ (YBCO) onto an appropriately textured template so that the grains in the YBCO are very well aligned with one another.



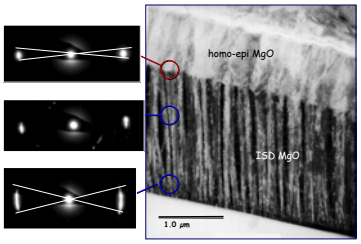


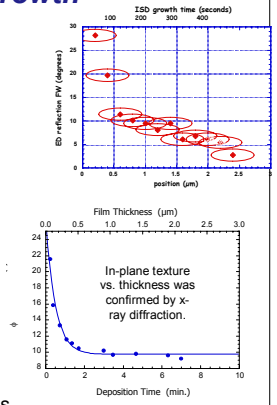
Inclined substrate deposition (ISD) of MgO has been adopted as an efficient and economical method to produce biaxially textured templates.

In this work we address key issues related to how the structure of these ISD template layers can be utilized for synthesis of coated conductors.

ISD template growth

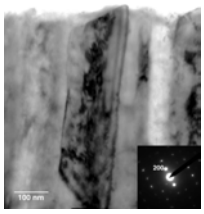
Electron diffraction (below) was used to measure the degree of texture (right).





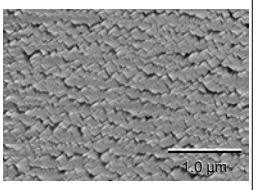
A critical ISD layer thickness of ~0.5 μm is sufficient to provide well-textured templates

ISD MgO morphology



Cross-sectional TEM image of ISD MgO

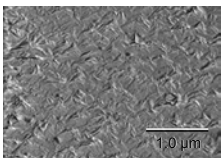
The ISD MgO structure is columnar (left). The column face is the (200) plane, leading to a terraced surface morphology (right).



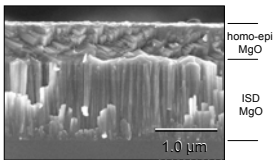
plan view SEM image of ISD MgO

Homoepitaxial MgO cap layer

A homoepitaxial cap layer of MgO yields a smoother surface and further improvement in texture

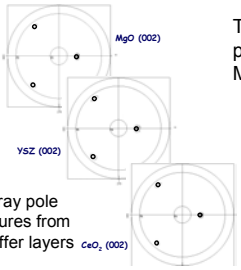


Plan view SEM image of homoepitaxial MgO on ISD MgO



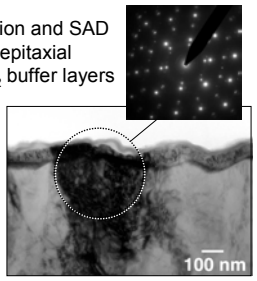
Cross-sectional SEM image of homo-epi MgO on ISD MgO

Texture propagation through buffer layers



X-ray pole figures from buffer layers

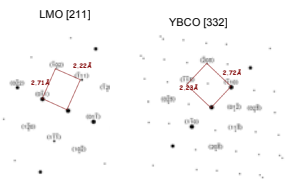
TEM cross-section and SAD pattern of homoepitaxial MgO/YSZ/CeO_2 buffer layers



"Cube-on-cube" epitaxial growth transfers texture through each buffer layer.

YBCO orientation relationships

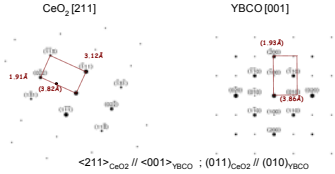
Deposition onto perovskite-terminated templates yields YBCO with an "inclined" orientation.



equivalent O.R. ⇒ $<001>_{LMO}$ // $<001>_{YBCO}$; $(010)_{LMO}$ // $(010)_{YBCO}$

i.e cube-on-cube texture as observed

Deposition onto CeO_2 (fluorite structure) yields YBCO films with c-axis parallel to surface normal



$<211>_{CeO2}$ // $<001>_{YBCO}$; $(011)_{CeO2}$ // $(010)_{YBCO}$

Crystalline anisotropy satisfied

Elastic energy minimized

While cube-on-cube growth occurs for YBCO deposition onto perovskite buffers due to a nearly perfect lattice match, a reorientation of YBCO is observed for growth on CeO_2 terminated surfaces due to the influence of crystalline anisotropy under more poorly lattice-matched growth.

Summary

- Texture development during ISD growth of MgO is rapid, reliable, and independent of substrate.
- An "optimum thickness" of ~0.5μm is based on sufficient texture with minimum surface roughness.
- Buffer layer crystallography plays a key role in determining YBCO orientation — either "inclined" and "c-axis" oriented films can be produced based on judicious choice of the underlying buffer layer.

This work was supported by the U. S. Department of Energy, Basic Energy Sciences and Energy Efficiency and Renewable Energy, under contract W-31-109-ENG-38. Electron microscopy was carried out at the Electron Microscopy Center at Argonne National Laboratory.

BES - DOE

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